National Aeronautics and Space Administration

The Winter 2010 and 2011 FRONT/NIRSS In-Flight Icing Hazard Detection Project

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Overview
- In-flight icing is a significant hazard to all aircraft
- Ground-based remote sensing is currently best method to detect the presence of icing

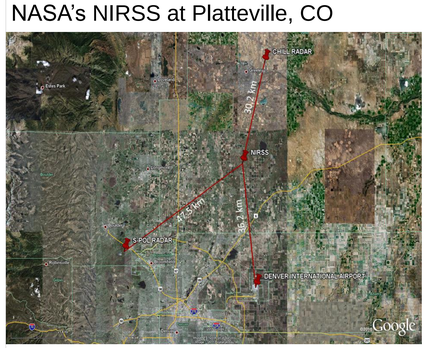
Objectives
- Test and develop prototype NASA Icing Remote Sensing System (NIRSS)
- Use NIRSS and PIREPs as verification of in-flight icing hazard, compare to polarized radar moment fields
- Examine feasibility of an 'Icing Hazard Level' Algorithm for the national network of polarized WSR-88 weather radars

Field Campaign
- Move NIRSS from NASA Glenn to Front Range of Colorado
- Locate NIRSS near 2 polarized research radars and under commercial flight path of Denver International Airport

NCAR's S-Pol radar at Boulder, CO

CSU's CHILL radar

NASA's NIRSS at Platteville, CO

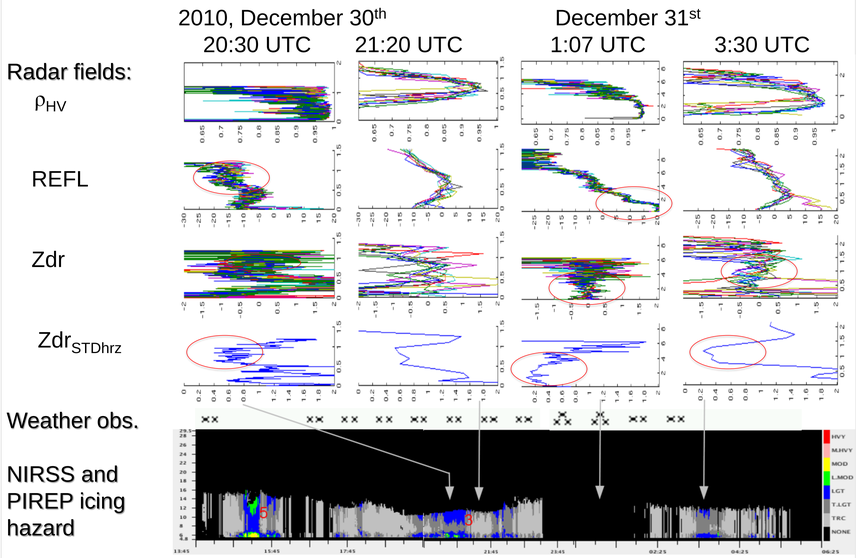


2010/2011 Field Campaign map

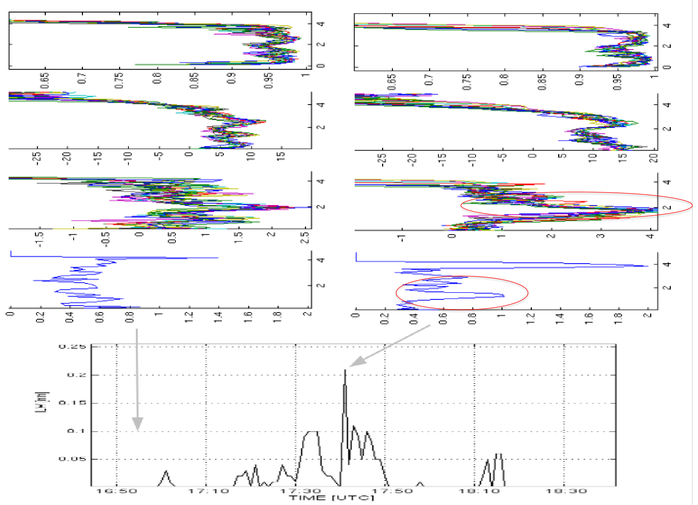
- 'Front-Range Observational Network Testbed' is S-pol and CHILL collaboration
- Radars collected range vs. height over NIRSS and volumes of constant elevation 360° scans during icing cases
- 250+ icing PIREPs collected over 25 different icing cases

Analysis

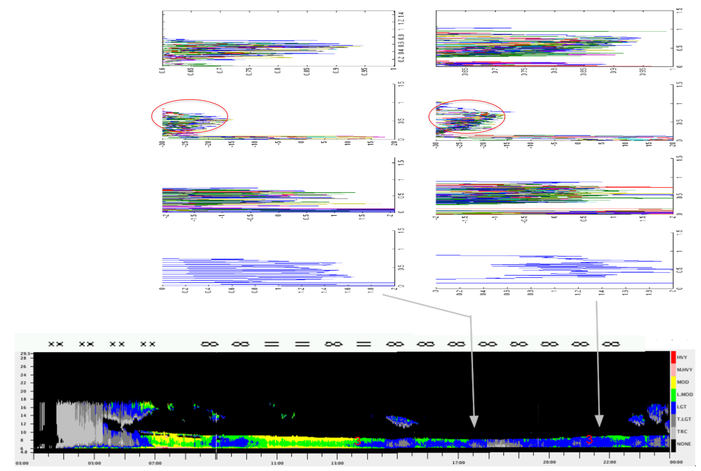
Method: Analyze horizontal and vertical radar moment fields from times of no icing and significant icing directly over NIRSS site (9 colored lines)



Case #1: light snow with icing, heavy snow with no icing
- Icing periods had low REFL, ~0 Zdr, low Zdr_{STDhrz} and light to no precip.
- Non-icing periods had high REFL, high ρ_{HV} , ~0 Zdr due to tumbling and VERY low Zdr_{STDhrz} due to homogeneous ice phase



Case #2: Cellular developing snow showers, intermittent icing
- Spike in integrated liquid corresponds to ρ_{HV} relative minima due to mixed phase, Zdr maxima and Zdr_{STDhrz} relative maxima below Zdr max as crystals scavenge supercooled liquid and snow showers form



Case #3: Significant small-drop icing in shallow, stratiform layer
- Surface reports of fog and mist
- Many icing PIREPs within 50 km radius of Denver
- Icing periods had REFL just above radar's minimum detectable signal
- Showed up on polarized radars as 'donut-shaped' rings close in to radars

Conclusions
- NIRSS did very well at detecting icing hazard times and severities
- NIRSS provided verification of presence/absence of icing for comparison to polarized radar moment fields during 2010/11 campaign
- Ways to classify icing with polarized weather radars in enhanced IHL:

'Homogeneous ice' –
- * REFL > 15 dBZ
- * ρ_{HV} > 0.92
- * Zdr variable, near zero for tumbling
- * $Zdr_{STDhoriz}$ small

'Homogeneous liquid' –
- * REFL < 0 dBZ
- * ρ_{HV} < 0.92
- * Zdr and $Zdr_{STDhoriz}$ possibly meaningless

'Mixed phase' –
- * REFL < 15 dBZ
- * ρ_{HV} variable, relative minima in SLW layers?
- * Zdr temporal large positive spikes for oriented ice growth near zero for imbedded supercooled layer
- * $Zdr_{STDhoriz}$ relative max below Zdr max small/relative minima for supercooled layer

Future Work
- Work to integrate NASA's Narrowbeam Radiometer into NIRSS
- More winter 2010/2011 case study work
- Integrate NIRSS findings into Icing Hazard Level algorithm

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